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Observation

by ROBERTO TORRETTI*

1 PRELIMINARIES

Sense perception is too variegated and complex to be a good starting point for the philosophy of science. Much of it is but barely cognitive. We are continually seeing whatever lies at the edge of our visual field, hearing the steady background noise of the city, touching our shirts with our shoulders, yet hardly ever have we derived any knowledge from such careless, confused perceptions. Nor shall we normally achieve any *scientific* knowledge through the diligent, discriminative perceptions that go into the contemplation of a work of art. I believe, therefore, that instead of trying to cope with perception in all its rich variety, the philosopher of science will do well to concentrate on the one form of it that is directly relevant to his subject, namely, the attentive, deliberate, explicitly cognitive mode of perception that goes under the name of *observation*.

To avoid needless exceptions to what I shall be saying, I restrict the meaning of the word to the observation of physical objects—in the widest sense, *i.e.* things, states, processes, events, and their properties and relations. This includes, *e.g.* the observation of where my back aches or how my heart throbs, but does not include the 'introspection' of disembodied mental states and processes, if there is such a thing. I shall also exclude from the scope of observation the access to physical objects by so-called extra-sensory perception (*ESP*).

I take for granted that observation always involves a physical process which links in a causal chain the object or objects observed to a physical

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system, that I shall call the *receiver*, in which the effects of the said process are recorded. Observation can be a source of knowledge only if it also involves awareness. Such awareness must be, of course, a state of a person, the *observer*, who is thereby enabled to learn from observation.

For want of a better word, I shall refer to observations with and without awareness as *personal* and *impersonal* observations, respectively. In personal observation the receiver is always the observer's body—or a part of it—but in impersonal observation it can be a wide variety of things: a photographic camera, a voltmeter, a telephone-bugging device, even a human being (*e.g.* the tasters employed in ancient courts to test foods for poison). For the result of an impersonal observation to become known, an observer must indeed eventually observe the receiver with his own senses.

In personal observation the observer always pays attention to something that is there before his eyes, or within reach of his ears, or at the tip of his fingers, *etc.* I call it the *direct object* of observation and say that it is being directly observed. The observer's main concern, however, may be something else, typically the object of an impersonal observation whose receiver he observes personally. I call this the *indirect object* of the personal observation, and say that it is indirectly observed by the observer. The distinction between direct and indirect observation is crucial to philosophers who wish to play down the importance of the intellectual factor in experience, or to deny it altogether. For it is plain that only direct observation might conceivably glean information from sense awareness alone, not supplemented by thought. In indirect observation the observer must rely on his previous knowledge—usually well padded with hypotheses—of the relation between the object directly accessible to him and the one he seeks to reach through it, in order to gain cognition of the latter through awareness of the former. But it is not easy to say just at what point observation becomes indirect, and hence dependent on memory and reason. It is clear that someone who alternatively sniffs the back of his hands to choose between two scents that have been sprayed on them practices direct observation, while someone who peruses a collection of cross-section *vs.* energy graphs looking for evidence of a new particle is involved in indirect observation. However, there are borderline cases in which the distinction between direct and indirect observation becomes fuzzy and can only be enforced by enjoining a strained reading of the definitions. Thus, I can test the hardness of a surface by pressing against it with the tip of my fingers, but, if I am not near enough I can also test it with the tip of a walking-stick I hold firmly in my hand. Shall we say that the latter is an instance of indirect observation because a dead stick is part of the receiver? But the stick plays a role in observation only in so far as it forms a single rigid system with my forearm; and the hardness of the surface is recorded in my joints, just as when I test it with my fingers. On the strength of a similar analogy, I shall say that I can read a definition of the *OED* no less straightforwardly with a powerful magnifying glass in the compact edition than with my ordinary eyeglasses in

the standard one—whereas reading with my naked eyes is a form of direct observation I have long ago learnt to avoid as being both tiresome and deceptive. Grover Maxwell [1962] built his claim that microscopic objects are directly observable on the gradual and seemingly continuous transition from 'looking through a window pane' to 'looking through a high power microscope'. However, as Ian Hacking ([1983], pp. 194 *ff*.) aptly reminds us, the analogy must break down somewhere on the way, because vision through a microscope does not repose on quite the same optical processes as ordinary vision: while in the latter information is relayed from the object to the retina mainly by the reflection, transmission and refraction of light, looking through a high power microscope essentially involves light diffraction and interference. Be that as it may, if thoughtless observation either does not exist or lacks epistemic value, the distinction between direct and indirect observation does not have much epistemological significance. (That the distinction is of virtually no importance in the actual practice of science is shown by the fact, rightly stressed by Shapere [1982], that physicists normally call 'direct observation' much that, according to the above stipulations, ought to be called 'indirect'.)

2 SOME FEATURES OF PERSONAL OBSERVATION

A personal observation involves a peculiar mode of awareness, distinct, say, from fear or recollection, and from other forms of perception, such as watching a movie, or basking in the sun on a beach. As words are used in English, a personal *observation* must also involve a physical process of some kind or other, by which the observed object acts on the observer's body. If this physical process of observation is lacking, a person who is aware of observing is said to hallucinate. Indeed one will disqualify as hallucinatory any case of purportedly observational awareness in which an object acts on the observer's body in a manner that would not normally bring about that awareness, *e.g.* if the observer is visually aware of a statue that he is touching in the dark.

We shall examine later the general characteristics of the physical process constitutive of observation, both personal and impersonal. But first let us take up personal observation alone, as it is disclosed in that mode of awareness which is proper and peculiar to it. Like other deliberate, attentive forms of consciousness, observational awareness involves *self*-awareness. The observer must somehow be aware of observing, or else he cannot properly be said to observe. (I say 'somehow' to make allowance for situations in which the observer is so absorbed by his task that he becomes oblivious of himself; even in such cases, if he is really observing, he will become aware of it as soon as he stops a moment to reflect on what he is doing.) Being immediate and not liable to control by others, self-awareness has often been pronounced incorrigible. This cannot imply, however, that every statement inspired by self-awareness exactly says what the speaker is

aware of, and neither requires nor admits improvement. Thus, when I now proceed to describe the structure of observational awareness, although I do not see how one could question my evidence for what I shall say—namely, my own self-awareness of what I call my observations—I do not doubt that one would find better words to convey that evidence.

I shall list some structural features of personal observation which, in my view, deserve special attention. Then, in the next four sections, I shall seek to elucidate them.

(1) Every personal observation is an episode in the observer's life. As such it takes time, it involves recollections and expectations, it is guided by the observer's memory and habits, and it is meant to serve his purposes.
(2) In every observation, the observer's attention falls on something he is currently aware of, which we have agreed to call 'the direct object' of the observation.
(3) The observer grasps the object—be it direct or indirect—as a particular instance of some universal.
(4) The direct object of observation is never simple. Its parts and aspects stand to one another and to other directly observable objects in relations of time and place.

3 PERSONAL OBSERVATIONS ARE EPISODES IN THE OBSERVER'S LIFE

If the analysis of this truism under (1) is granted, there can be no such thing as an instantaneous, simple, isolated, presuppositionless or purposeless personal observation. This disjunction sets definite limits to the claims of empiricism. Knowledge cannot rest on observation alone if all observation is conditioned by the observer's interests, preferences, beliefs and former knowledge.

Note that I do not assert that all *perceptions* are thus conditioned. It might be plausibly argued that the earliest perceptions of babies are assumptionless and value-free, if only because they are the earliest, and are still too vague and unexpected to fall into any kind of order. Against such arguments we need not resort to our different but probably no less dubious insights into the minds of babies. It is enough to point out that such earliest perceptions are not observations, and that, even though they may help to build habits which will later support the cognitive use of the senses, they can hardly be said to yield knowledge.

On the other hand, it seems to me fairly obvious that no mode of human awareness can lack duration or complexity, or can exist in isolation (although this too has been questioned, as Peirce [1931–58], Section 7.629, recalls). This holds therefore for all perception. However, Hume asserted that our senses 'convey to us nothing but a single perception, and never give

us the least intimation of anything beyond' (Hume [1739], p. 189). I do not find that Hume's claim does justice to my observational awareness. Anything that I am capable of distinguishing as a 'single perception'—be it the furry surface of the carpet under my feet, or the colourful backs of the books on the shelf in front of me, or the shrill sound of the car alarm beaming from the parking lot beneath my window—points *as such* to a multitude of things beyond it. It may be argued that it does not do so of itself, but only because it is woven into a complex of experiences and expectations in the midst of which it turns up as a perception. But if I shut myself from, or ignore, or 'forget' that complex, there would be nothing left for me to pinpoint as a 'single perception'. Thus, except for the marginal cases we shall consider near the end of Section 4, whatever my senses succeed in conveying to my attention is self-transcending—it is a signpost cluttered with intimations of the world.

4 THE DIRECT OBJECT OF OBSERVATION

Though nobody doubts that any observation has a direct object, there has been much controversy about its nature. Let me introduce the issue through an example. I own two pairs of eyeglasses which enable me to focus my eyes at different distances. Suppose now that I stand in Madrid's Plaza de Oriente and want to decide which of my eyeglasses will be most suitable for examining the statue of King Philip IV. I wear them alternatively and try to ascertain which of them gives a clearer view of the embroidery at the tip of the King's sash. The question in dispute can then be put as follows: When I change glasses, do I change the direct object of observation, or only the aspect or guise under which I see it? If we are to abide by ordinary English usage, there is no doubt as to the right answer to this question: My attention has been directed all the time to the same bronze sash, hanging motionless from the statue above me, and it looks slightly different, now neater, now woolier, because I see it through different glasses. However, some philosophers have wished to reform ordinary language at this point, at least for the purposes of philosophical discourse, and would have us say, in the case of my example, that the direct object of observation, *i.e.* the object I am currently aware of and paying attention to on each occasion, is the multiply connected black spot at the centre of my visual field that I take to be an aspect or *Abschattung* of the sash, and that, since the spot is sharper when I wear one pair of glasses, foggier when I wear the other pair, it is evident that the direct object of observation is, on each ocasion, a different one. As to the statue, such philosophers would say that—regardless of what, if anything, it may be in itself—as an object of human knowledge it is constructed from the aforesaid and many other likewise directly observed objects and also perhaps from non-observational ingredients.

We need a collective name for the entities to which direct personal observation is confined by our language reformers. 'Phenomenon' is a time-

honoured name for them, which instantly yields 'phenomenalism' as a denomination for their sponsors. But 'phenomenon' is currently used for physical occurrences which a person can only observe indirectly, by means of thoughtfully contrived devices (*cf.* Hacking [1983], pp. 220 *ff.*). I shall therefore call them sense appearances, although this name also suggests some wrong connotations.

To my mind, the main motive for restricting the immediate scope of personal observations to sense appearances is that one thereby secures for its direct objects a purity from intellectual contaminants that cannot be matched by the material bodies which, in plain English, we are said to observe directly. I shall describe some imaginary—yet practically unimaginable—situations to which one would willingly apply the new language or in which one might dismiss the entire issue as a purely verbal one. The difference between these situations and our own condition will make clear, I hope, why the proposed reform is not viable, why we cannot persist in speaking, for any significant length of time, as if our senses made us aware of sense appearances only.

Consider a purely contemplative observer, who sees static scenes, one after the other. He would have little or no inducement to analyse the scenes into parts or to associate parts of different scenes, unless such parts happened to be equal. In the latter case, there would be no reason for distinguishing the object of observation from its momentarily perceived aspects. Suppose now that the scenes observed change gradually and flow into each other, as in a motion picture. The observer could then perhaps discern patterns in the flow and come to view parts of successive scenes as diverse aspects of the same object. Such an object, however, would be no more than the series of its presentations, or rather the law of that series. A Humean analysis—which the circumstances obviously would call for—would unmask such laws, exposing them as mere habits. We can add sound and even smells to the motion picture without changing the situation essentially. We humans differ, of course, from a purely contemplative observer in that we have an interest, often a vital one, in the objects we perceive, and are sometimes also able to change them. But even if we let our fictitious observer resemble us in this, if we allow, say, some of the movie sequences which are all his experience to become pleasant or painful, and we let him will and occasionally achieve the removal of pain, the renewal of pleasure, he still would not be one of us. For he lacks the complex array of muscular, postural, thermal, tactile experiences in which we perceive ourselves as bodies, incessantly interacting with other bodies, dangerously exposed to them, and also, through that very interaction, capable of manipulating them and observing them. The pencil I hold in my hand and press between my fingers, the chair I sit in, the table I write on, are grasped in observation as true bodies because through the pressure I exert on them, the movements I do against them, the thermal gradients they generate on my skin, I sense their bodily presence on a par with my own. Dr Johnson refuted

Berkeley by kicking a stone. The Greeks fought Pyrrho's sceptical doubts by letting a dog loose on him. Professionals smile with condescension at such wordless arguments, but there is a wisdom in them. Macbeth would clutch the dagger which he saw before him, or else dismiss it as 'a dagger of the mind'.

Awareness of our interaction with the bodies surrounding us is the key to our construal of personal observation as a physical process, with our body as the receiver. It is convenient to recall how this construal introduces a measure of order and consistency into the diverse and often baffling appearance of things. If the observer becomes aware of the physical objects about him by their action on his body, his observational awareness must depend not only on the objects themselves, but also on the condition of his body and all other circumstances influencing the observation process. Thus, our grasp of the physical basis of vision enables us to understand why a Gothic steeple should appear so different through the fog or under a blazing sun, why a perfectly straight pencil should show a kink when partially submerged in a glass of water, why the police van catching up with my car should turn up in the mirror in front of me, why a supernova should flare up in the sky now in the direction where it faded out forever several million years ago. On similar grounds we can account also for our seeing visibles (and hearing audibles, *etc.*) which are not judged to be an aspect of anything, such as the red, semitransparent dics that we see wherever we direct our eyes after we have been looking intently for a while at a strong source of light, or the colourless little worms that we see wriggling about in the air if we stare at a bright cloudy sky. Since visual (acoustic, *etc.*) awareness closely depends on the state of our body it is to be expected that it will often be stirred by changes in that state which are not a part of any process of observation (just as, say, a short-circuited loudspeaker will emit a noise which is not a part of the music being played). It is fortunate, indeed, that such occurrences, though frequent, rarely become obtrusive. But it is a perversion of philosophy to choose such marginal events as the prototype of all our sense experience, and then to wonder how it may come to pass that by far the greater part of it is so neatly ordered as a display of physical objects. In fact, outside this order in which we normally perceive things in their manifold aspects, it is hard to conceive that there could even exist an awareness of objectless *sensibilia*.

5 CONCEPTUAL GRASP OF THE OBSERVED OBJECT

Throughout the preceding discussion I have implicitly appealed to the principle stated on page 4 under (3): *The observer grasps the object as a particular instance of a universal.* By this I do not mean to deny that we do in certain circumstances perceive individuals as such, and not as members of a class. When talking to a close friend, or laughing together, or holding her or him in our arms, we are often aware only of the unique individual we are

with, and not of any universals that she or he instantiates. Awareness of individuality in its irreplaceable oneness is, I surmise, a necessary condition of any genuine personal relationship. I contend, however, that such awareness is not observational, and that as soon as one begins to observe one's partner, her teeth, her accent, her syntax, one does in effect subsume her, or at any rate that aspect of her which one is observing, under a general concept. This feature of observation which, for brevity, we may call the principle of conceptual grasp, holds for all objects of observation, both direct and indirect. It is indeed especially obvious in the case of impersonal observation by means of artificial contrivances. Such artifacts cannot properly yield data unless the observer conceives of them as physical systems of a certain kind, which interact according to certain laws with objects of the class under investigation. It is therefore well nigh impossible to figure out how observation can be a source of science, unless it obeys the principle of conceptual grasp, and the observer *qua* observer approaches the particular objects of observation with a view to their generality.

If concepts go into every observation, then empirical knowledge is intellectual through and through. This was already implicit in Kant's dictum that sense awareness without concepts is blind. It raises several philosophical problems, on two of which I shall briefly touch now.

The first is the problem of noogony, or the origin of concepts. These cannot *all* be obtained *from* observation by the classical procedures of comparison, reflection and abstraction. In each observation some concepts must be at work from the very outset. Each time we revise a judgment some concepts must remain stable. Every exercise of our understanding thus involves concepts which are, so to speak, locally *a priori*. We need not hold that any concepts are permanent, or global in scope; but it is clear that the doctrine that all concepts proceed from observation would entangle us in an infinite regress.

The second problem I wish to mention can be stated as follows: Every conceptual grasp of an object of observation is liable to revision and correction in the light of other observations. What justifies our preference for some observations above others? How can we judge that we have achieved a better conceptual grasp? This problem was miraculously solved—or rather dissolved—by the positivist dogma of Immaculate Perception, according to which we can observe virgin data, unpolluted by our fallacious intelligence, and adjust our concepts and judgments to them. If we could ever make a perfectly self-contained observation, not signifying anything beyond itself, there would certainly be no means—and no motive—for revising it. One would just blow away the conceptual chaff and leave the observational grain alone in its Parmenidean immutability—and irrelevance. But, as a matter of fact, none of our observations can be thus isolated. Each of them is constitutively linked by concepts to other observations welded into a complex network of assumptions and beliefs, together with which it gives rise to a wealth of expectations. Failure of

expectations is ultimately perhaps the only inducement for revising and correcting our observations. But the revision of an observation is not effected only in the light of posterior observations of the unexpected. It is usually assisted also by the record of other past observations which may be more detailed, more careful, or more consonant with each other. Consonance and detail yield unquestionable, more or less unambiguous criteria of preference. But to say that an observation is more careful than another one would seem to presuppose the choice that we seek to justify. However, some observational procedures may well be deemed more careful than others if they normally lead to more successful expectations. Moreover, our present, well-corroborated understanding of the physical processes of observation provides definite and, within that understanding, unimpeachable grounds for judging the reliability of observations. How one goes about using such diverse criteria in the progress of experience is well known to us from our daily lives. More sophisticated examples are provided by the history and the current practice of scientific research. By recalling these generalities about the revision and mutual illumination of observations I am not trying to usurp for philosophy the role of the scientific methodologist—who sifts and systematises the procedures for collating observation data and the criteria for judging their worth—but rather to clear the way for him. What we ought to bear in mind is that, if all our knowledge of physical objects is corrigible, it must be *self*-correcting, for there is no outside authority to which one could turn for help. I find therefore that, important as it is, Quine's recognition that 'our statements about the external world face the tribunal of sense experience not individually, but only as a corporate body' ([1961], p. 41) is not sufficiently thorough. For in the trial of empirical knowledge the defendants are at once the prosecution, the witnesses and the jury, who must find the guilty among themselves with no more light that they can all jointly put together.

6 OBSERVED RELATIONS OF TIME AND PLACE

Relations of time and place are among the most pervasive universals under which physical objects are grasped in observation. There is no question that, if we directly observe physical objects, such relations between them are also observed directly. As I stand *in front of* a class I see *rows* of students sitting *at* their desks *between* me and the *back* wall. I see a student *raise* both his hands, one *after* the other, and then *simultaneously* put them *down*. This is the proper way of describing in ordinary English what I see, and I can discern no reason to reform it. Indeed, even those who maintain that physical objects are not observed directly, but are constructed from sense appearances, would normally grant that the latter stand in directly observable time and place relations of their own. I shall discuss some such views in the second half of this Section. But first let us proceed along the common sense line we have been following.

In any observation I grasp the direct object of my attention amidst other physical objects—always including my own body—to which it stands in more or less definite relations of place and time. It is a familiar fact of life that the place and time relations involving diverse objects personally observed by different observers on different occasions mesh together into a single relational net on which each observer has, so to speak, a permanent grip. Consonance with this network of time and place relations is one of our preferred criteria for judging our grasp of particular observations. It is chiefly through the steady presence of this network that the world of *possible* objects of personal observation is held as a permanent background to whatever we happen to be *actually* observing. Thus, when I stand in the classroom where I usually teach, looking at the door, I expect to find behind it the corridor leading to the stairs that go down to the street where my car is parked. Of course, it could turn out that while I spoke in the classroom the rest of the city had been wiped out by a surgical nuclear strike; but I would expect to find behind the door, even in that case, the place where the corridor had been. Annihilation of that place itself, though not a logical impossibility, cannot be contemplated without a drastic change in the very concepts with which we grasp our surroundings.

Like other relational systems, the network of time and place relations between directly observable physical objects may be conceived as an abstract structure by ignoring the irrelevant peculiarities of the entities that actually hold the relations. This can be done as follows: Let us say that two directly observable physical objects are *P-equivalent* (*P* for *place*) if they can exchange places while all relations of place between directly observable physical objects remain otherwise unchanged. (In other words, two such objects, A and B, are P-equivalent if and only if the truth-value of every proposition concerning relations of place between directly observable physical objects remains unchanged when A and B are annihilated and recreated at each other's place and the references of all names of A and B are mutually exchanged.) P-equivalence partitions the world of directly observable physical objects into P-equivalence classes. We regard all members of a given P-equivalence class as copies of a prototype and forget their individual differences. The list of P-equivalence classes and the relations of place between members of such classes is then a structure, which we may call the *space of direct observability*. The structure thus conceived would be quite unwieldy, but it could be greatly simplified if one succeeded in defining all P-equivalence classes in terms of a few. In a similar way, we might characterise T-equivalence (T for *time*) and PT-equivalence (PT for *place-and-time*) between directly observable physical objects in terms of their mutual replaceability with respect to time relations or with respect to place and time relations, respectively. These equivalences would then generate two structures which we may call the *time* and the *spacetime* of direct observability.

Assuming that the said structures are conceivable, one may ask what

relation exists between the time, the space and the spacetime of direct observability and the familiar time, space and spacetime manifolds in which mathematical physics deploys its objects. To give an inkling of what is at stake with this question, I shall sketch three conceivable answers. For brevity's sake I shall speak only of the relation between the spacetime of direct observability (*STDO*) and the spacetime of mathematical physics (*STMP*); the other two pairs of structures can be treated similarly. The most straightforward answer is that *STDO* is an open submanifold of *STMP*. It entails that every directly observable event has a neighbourhood in *STDO* which is homeomorphic to $\mathbf{R}^4$—a rather strong requirement, implying that any observable time lapse is not only infinitely divisible, but also continuous in the strict mathematical sense. Another, less stringent answer is that *STDO* can be identified in a reasonable, non-trivial way to a structure obtained by choosing some suitable subset of *STMP* and restricting to it the constitutive relations of *STMP*. In this case, *STDO* could be said to be embedded in *STMP* in the same sense in which a finite geometry consisting, say, of a few dozen coplanar points and lines, plus their relations of incidence, concurrence and collinearity, is embedded in the Euclidean plane. *STMP* would then be essentially richer than *STDO* but in every way compatible with it, so that we could say that *STMP* is an extension of *STDO*. A third answer seems to me more plausible than the former two, namely, that *STMP* is an extension not of *STDO*, but of an idealisation of *STDO*, *i.e.* of a structure defined by ignoring some constitutive features of *STDO* (*e.g.* the direction of time), and resolving by *fiat* the fuzziness of others (*e.g.* metric relations between observed objects).

If one believes that only sense appearances are directly observed and that physical objects are constructed from them by the human mind, it is natural to assume that the place and time relations of the different types of sense appearances constitute distinct structures—*viz.* a visual space, a tactile space, *etc.*—and to inquire into their peculiarities. It is indeed surprising that such inquiries should hitherto have been confined to place relations only, and that we have yet to hear about separate perceptual times, or spacetimes. It has been claimed repeatedly, on the strength of both armchair philosophy (Reid [1764]) and experimental psychology (Luneburg [1947], Blank [1953], [1958*a*,*b*], Battro *et al.* [1976]), that visual space, *i.e.* the abstract structure of place relations between visual percepts, has a definite geometry, incompatible with the geometry of physical space developed by common sense and perfected by mathematical physics, seemingly on the basis of haptic (tactile and kinaesthesic) perceptions alone. Such a radical distinction between visual and physical space provides a very strong argument for the thesis that physical objects are not seen but inferred. It can also yield plausible solutions to some classical puzzles regarding visual illusions and multiple or delayed images. If the places I see or hear correspond to but are not identical with the places among which I stand and

move, I should normally expect some measure of incongruence between their respective contents.

Now, while Reid—followed in our days by R. B. Angell [1974]—maintained that visual space is a two-dimensional spherical space, Luneburg and Blank claimed that it is a hyperbolic three-dimensional space, and Battro and his associates attributed to it a three-dimensional Riemannian geometry of non-constant curvature (ranging from $+1$ to -1). In the light of what I said about the relations between *STDO* and *STMP* it should at once be clear that such claims cannot be taken literally, for a Riemannian space of two or three dimensions and either constant positive, constant negative or non-constant curvature must anyway have a topology and a differentiable structure which no visual data can warrant, and also implies exact metric relations which can only be roughly approximated by the gross estimates of size and distance that unaided vision is capable of providing. Thus, the most that can be claimed by the rival theorists of visual space is that their favourite geometries are optimal idealisations of the structure displayed by visual percepts. My reservations with regard to them arise not so much from their mutal disagreement as from the nature of their methodologies. I do not think that one can reach valid conclusions about what a healthy grown-up person normally sees, by reasoning *a priori* from the premise that the human eye works like a movie camera turning on a fixed pivot, or by collecting laboratory data under such far-fetched experimental conditions as I shall describe below.

Reid builds *a priori* his 'geometry of visibles' on the assumption that visual appearances are placed about 'the eye'—in his chapter on the subject Reid writes this word in the singular, as though he were philosophising about Cyclopes—which knows nothing of their radial distances, but ditinguishes the directions in which they lie. As 'the eye' rotates about its centre, the places it sees range over a two-dimensional Riemannian manifold, isometric to the sphere. To reach this conclusion, Reid must tacitly presuppose that 'the eye'—unaided by manual operations with tangible instruments—is able to measure the angles subtended by the visual appearances. This it can certainly do if it can keep track of its own rotations and can match them with the displacements of the centre of the visual field. Reid's ideal eye—which we ought to imagine, I guess, as freely rotating in a static, transparent socket—may just as well be endowed with this faculty, whose exercise and application to the 'geometry of visibles' must, however, contaminate the latter with haptic features. Evidently Reid's construction depends, unbeknownst to him, on the simple mathematical fact that, under the stated assumptions, the group $SO(3)$ of rotations about a fixed point in Euclidean 3-space induces a spherical geometry in the visual field. A motionless eye, surrounded by a topologically compact, simply connected, two-dimensional visual field, would have no grounds for bestowing on it a spherical geometry or indeed any metric at all—unless some further assumptions are made.

Luneburg sought to ascertain the exact implications of *two*-eyed vision for the geometry of visual space. He purportedly achieved this aim by analysing the results of some clever experiments, in which the subject is placed in a dark room before diverse configurations of luminous points. While 'motion is avoided by fixing the subject's head in a headrest and he is exposed only to static stimuli', 'no artificial restriction is placed on the subject's binocular function'; he 'makes his observations by allowing his eyes to rove at will over the entire range of the stimulus configuration until a stable perception of the geometry of the situation is achieved' (Blank [1953], p. 717). In one of the experiments—designed and carried out by A. Blumenfeld as early as 1913—the subject is presented with two rows of luminous points, symmetrically disposed on either side of him, by pairs, on the horizontal plane of his eyes. The subject can move each light along a horizontal line perpendicular to the vertical plane dividing his left from his right side. He is asked to leave a given pair where it stands, and to reorder the others so that he gets to see either (*a*) a *distance alley*, *i.e.* two equidistant rows of luminous points receding from him; or (*b*) a *parallel alley*, *i.e.* two straight rows, perpendicular to the vertical plane dividing his front from his back. If the geometry of binocular vision were Euclidean arrangements (*a*) and (*b*) ought to coincide. The discrepancy between them—as noted by the experimenter in his own haptic space—allegedly proves that the subject's visual space is not Euclidean but hyperbolic.

Troubled by the extreme artificiality of Blumenfeld's experiment, Battro and his associates repeated it under much more liberal circumstances. The subject, though still bound to a chair, was allowed to move his head, not just his eyes. He was placed in the open air, by daylight, facing an alley of up to 240 m long and 48 m wide, formed by 5 to 12 pairs of yellow wooden staves 1 m or 1.5 m high. The two staves at the end of the alley were fixed and the subject was requested to tell the experimenter how to move the remaining staves to the left or to the right, until the subject saw either a 'parallel alley' or a 'distance alley', as defined above. Again the discrepancy between both arrangements was supposed to reveal the geometry of the visual field, but, 'contrary to commonly accepted results that binocular visual space is homogeneous and has a negative curvature, and therefore a Lobachevskian geometry', Battro and his associates 'observed that the regular alleys gave the three possible curvatures of space depending on their size, the particular setting and the subject'; whence they concluded 'that a general Riemannian geometry of variable curvature would be more compatible with the individual visual data' (Battro *et al.* [1976], p. 14). Their tabulated results lead me, however, to a somewhat different conclusion. For what I read, for instance, in their Table 6 is that for different choices of a subject and of a setting of the fixed staves, the measured curvature of binocular visual space took one or the other of the five *constant* values 1.0, 0.5, 0, −0.5 and −1.0. Since the method followed does not yield the curvature of visual space at one or more select points, but—if anything—its global curvature over a region

containing the staves, the stated results cannot be said to characterise a *single* space of variable curvature, but—if anything—*several* spaces of diverse but constant curvature.[1] Hence, to my mind, the visual geometry disclosed by such experiments is not a feature of reality to which one might have to adjust one's conduct in life, but an artifact of the experimental procedure.

Be that as it may, it is worth noting that if a 'geometry of visibles' wins general acceptance and we are finally led to agree that visual phenomena belong to a space of their own, which is structurally incompatible with the one in which haptic phenomena are localised, we shall have to learn to say that a batsman who sees a ball fly towards him should try to hit, indeed, that same ball, but in a different space. Although I do not dispute that intellectual progress can sometimes be secured only through language reform, I refuse to believe that such a strained use of the words 'same' and 'different' could ever be justified, let alone sustained.

7 OUR UNDERSTANDING OF THE PROCESS OF OBSERVATION

In observation the observer grasps his own body in physical interaction with the objects observed. This is a permanent ingredient of observational awareness, at least where haptic perceptions are at play. Such being throughout our lives virtually always the case, it is no wonder that, in ordinary usage, the statement that a person x observes a thing or event y implies the statement that y causes x to be in a state in which he succeeds in observing it. Indeed this usage extends to all modes of observation, visual, auditive, *etc.* even where no reference is made to haptic awareness. I do not take this linguistic practice to mean that, say, purely visual observations—if

[1] The matter is more involved than my hasty discussion suggests. Let A and B denote the positions of the fixed lights or staves in the alley experiment. In both the dark room and the open air version, the sought for curvature of visual space is determined by comparing, *in the experimenter's haptic space*, a pair of lines through A and B whose images in the subject's visual space are *equidistant* from each other, with a pair of lines through A and B, coplanar with the former, whose images in the subject's visual space are *straight* and *perpendicular* to the segment AB. To be meaningful, the comparison must presuppose that 'equidistant', 'straight' and 'perpendicular' describe definite features of the subject's visual experience, so that, when he redistributes the lights or the staves in agreement with such predicates he is not guided merely by an estimate he would do well to verify with a measuring rod or some other haptic means, but by a purely optic perception of lengths and angles. If this somewhat venturesome presupposition is allowed, the comparison can yield a definite value k for the overall Gaussian curvature of the visual surface corresponding to the haptic plane on which the lights or staves are placed. The procedure only makes sense if the said Gaussian curvature is constant. k is relevant to the geometry of visual space if and only if the said visual surface is totally geodesic. In that case, k is, at each point of the visual surface , one of the local sectional curvatures that enter into the construction of the Riemann curvature tensor of the visual space at that point. (*Cf.* O'Neill [1983], p. 104, Def. 12; p. 101, Cor. 6; p. 79, Cor. 42.) But, since k is only *one* of the local sectional curvatures, it does not suffice to determine the Riemann tensor, unless we assume that the curvature of the visual space is constant. This assumption, of course, was made and argued for by Luneburg and Blank, but is avoided and finally rejected by Battro and his associates. The meaning of their measurements is thereby obscured.

there are any such—must involve a claim to being caused by their objects (except perhaps when they are on the verge of being painful due to excess of light, in which case vision becomes propioceptive like touch and kinaesthesia).[1] But visual observations are made by us, men and women of flesh and blood, who must sit or stand or walk or run or turn or stoop or stretch or, at the very least, strain our eyes to see. Haptic awareness is thus pervasive and discloses, in one way or another, that we are committed to the physical world. Our everyday handling—holding, pressing, pulling, pushing, twisting—of all sorts of bodies, and our continual exposure to bumping and falling, heat and cold, wind and water, light and noise, furnish the prototypes of our original notions of physical existence and physical action. It is therefore very unlikely that we shall ever find occasion of rejecting our grasp of ourselves as bodies interacting with other bodies.

Yet, while men have never seriously hesitated in their grasp of observation as a physical process, their general understanding of such processes has undergone great changes. For example, Aristotle conceived of a manner of physical action that was designed to account for perception and observation. By virtue of it, the constitutive 'form' of the observed object could be transmitted 'without matter', through an appropriate intervening medium, to the 'sensitive faculty' of the observer. (For a curious example of how the observer's properties, in turn, would also be communicated 'without matter' to the object of observation, see Aristotle, *De Somnibus*, $459^{b}27$ *ff.*) This doctrine was taught at school to the founders of modern science, who later rejected it and replaced it by a different conception of physical action which in part revived pre-Aristotelian notions. Towards the end of the seventeenth century the new conception had taken such hold of the best minds in Europe that, for example, John Locke 'found it impossible to conceive that body should operate on *what it does not touch* [. . .], or when it does touch, operate any other way than by motion'.[2] Whence, when he comes to consider 'how bodies produce ideas in us', he declares that it 'is manifestly by impulse, the only way which we can conceive bodies to operate in'.[3] This early modern idea of physical action was considerably modified by

[1] J. R. Searle [1983], p. 124, n. 9, proposes the following thought experiment to help remove the doubts of 'many philosophers' who are prepared to agree with him that 'causation is a part of the experience of acting or of tactile and bodily perceptions', but 'do not concede that the same thing could hold for vision': 'Suppose we had the capacity to form visual images as vivid as our present visual experiences. Now imagine the difference between forming such an image of the front of one's house as a voluntary action, and actually seeing the front of the house. In each case the purely visual content is equally vivid, so what could account for the difference? The voluntarily formed images we would experience as caused by us, the visual experience of the house we would experience as caused by something independent of us.' But evidently the alleged conclusion of Searle's thought experiment follows only if we beg the question and *assume* that visual images must be experienced as caused. Otherwise, the most we can conclude from Searle's conditions is that involuntarily formed visual images would be experienced as *not* caused by us.

[2] Locke, *An Essay Concerning Human Understanding*, editions 1 through 3, II. viii. 11.

[3] Locke, *An Essay* . . ., 4th edition, II. viii. 11; *cf.* IV. ii. 11.

successive generations of natural philosophers, first by the eighteenth century theorists of instantaneous action at a distance, then, in the nineteenth century, by the creators of field theory. One capital ingredient of it survives, however, to this day: for us, as for Descartes, Boyle, Huygens, *etc.*, all physical action boils down to a transfer of momentum—or, as we would rather put it now, of 4-momentum.

The modern philosophy of nature has presided over great advances in the physiology of perception. It has also been associated, from its inception, with the modern development of means and methods of impersonal observation, which not only have tremendously expanded the scope of our knowledge, but should also help us, through our growing familiarity with them, to achieve a better grasp of the nature of personal observation. On the other hand, the modern idea of physical action has burdened us—also from its inception—with the so-called mind-body problem. For, as the seventeenth century occasionalists were quick to see, transfer of momentum will neither account for nor be explained by a change of mind. All the attention devoted to the problem since Descartes has not brought us any nearer to understanding how a man's decision can initiate a definite outward flow of energy and momentum across his skin, or how an inward energy-momentum flow across it can modify his state of awareness. And we still do not know how to coordinate our particular states of awareness of directly observed objects with any well defined, particular effects of the action of such objects on our bodies. It is unlikely that this rift between the two sides of observation can be closed without some radical, incalculable innovations in our understanding of physical action. Since our current understanding lies at the heart of so much valuable knowledge, there is little inducement to change it.

Even if our present understanding of the observation process is thus limited and beset with difficulties, we are deeply committed to it, and we cannot well imagine how some of its implications could be denied. Thus it seems clear that, no matter how we conceive physical action, in every observation the observed object interacts with a receiver. Such interaction is critical to the acquisition of knowledge by observation, for the observer cannot ascertain any more features of the observed object than become discernible to him through their recorded effect on the receiver. Indeed, a state of the receiver can furnish information about a feature of the object observed only to the extent (and within the range of ambiguity and imprecision) that the said feature is, under the circumstances, a necessary condition for the attainment of that state. The receiver's 'power of resolution', its capacity to separate—or its tendency to blur—the imprint of different attributes and states of the object, is a measure of its cognitive value. From this point of view, impersonal observation, carried out by means of an increasingly varied and efficient panoply of precision instruments, enjoys a distinct advantage over personal observation, although it cannot come to fruition without the latter.

8 PERSONAL *VERSUS* IMPERSONAL OBSERVATION

The philosophical posture of modern science demands that nature be all of one piece. Observation processes have no doubt their peculiarities, without which they might not serve their purpose, but they are not specifically different, as natural phenomena, from other physical processes which are not observational. Observational interaction instantiates the same types and is governed by the same laws as ordinary physical interaction. Indeed, the development of impersonal observation in the modern age could only get under way on the understanding that such was the case. Observation devices exploit known properties of well typified natural processes for the sake of collecting information. Inference from the state of the receiver to the state of the observed object must rest on our knowledge of those properties, and can therefore hold good only if observation processes are not, physically speaking, a class apart.

Nonetheless, observation processes do differ from their non-observational analogues in that they are ordered to an end: they are always embeddable in a quest for knowledge. It is a requisite of this teleological order that, among the many factors that contribute to a physical process of observation, some should stand out as the objects of observation and their observed features, while others constitute the receiver and its data-recording states.

In impersonal observation, the receiver is usually artificial and is singled out by its human manufacturer. It is expressly designed to register the interesting effects of the intended object of observation, which has been previously singled out by some human research project. Since the object-receiver interaction is nevertheless immersed in nature's flux, great ingenuity must usually be devoted to filtering out the 'noise' that hinders the clean flow of information from the object to the receiver. The status of these several items is indeed notional, and depends on the epistemic project which the observation is meant to serve. (*Cf.* Pickering [1984].) The cognitive significance of the receiver's states is a matter of interpretation, depending, of course, on the circumstances of the observation, but also, decisively, on the observer's intelligence of the experimental situation. On the frontier of research such intelligence is apt to be flimsical. Thus, for example, the negative result of Michelson's famous attempt to measure the relative motion of the Earth and the ether was understood to indicate (*a*) that the ether is dragged by the Earth's atmosphere, the protective box in which Michelson's apparatus was contained, *etc.* (this was Michelson's own conclusion in 1881); (*b*) that motion of the apparatus across the ether modifies the molecular forces that hold its parts together, shortening one of its perpendicular beams while merely narrowing the other (this was independently suggested by Fitzgerald and Lorentz); and (*c*) that we live in a Minkowski spacetime in which light pulses *in vacuo* follow null worldlines, so that the speed of light measured on an inertial lab in which time is defined

by Einstein's method is the same in every direction. (*Cf*. also the example—beautifully analysed by Shapere [1982]—of the observation of the Sun's interior by means of neutrinos, in which the object and the instrument of observation are delicately suspended in a tenuous spiderweb of theories.)

While the cognitive aim of an impersonal observation supervenes on its underlying physical processes by the initiative of men, teleology is, so to speak, endogenous to personal observation. Here the receiver has not been segregated from the mainstream of nature for fact-gathering purposes by an external agency, but has grown of itself into a distinct, fairly stable physical system, suitably disposed to pick out specific effects of its interaction with specific objects. The cognitively relevant receiver states are not presented on a dial to the observer's interpretative acumen, but translate spontaneously into observational awareness. The objects of personal observation do not have to be inferred from the states they induce in the receiver, for they are simply and straightforwardly perceived. In fact, it is rather from his direct awareness of them that the observer eventually learns—by inference—what receiver states are instrumental to their observation. Thus we have come to know that—though we are still quite incapable of explaining how—the recorded difference of less than 1/3000 s between a sound's arrival in our left and in our right ear is the source of our awareness of the direction from which the sound came; that our visual awareness of the volume of nearby bodies rests on the slight difference in the optical input from such bodies into each one of our eyes; that our sense of balance and orientation in the gravitational field in which we live depends on the flow of liquid along the sensitive walls of the semicircular canals in the internal ear.

We normally have a more or less definite grasp of the direct objects of our personal observations, and of their relations of place and time and in some cases also of their causal relations with our bodies. This grasp is the source from which the theory and practice of impersonal observation ultimately draw their sustenance and motivation. Thus, personal observation may justly claim metaphysical priority over impersonal observation. But that does not bestow on it an epistemic privilege against the latter. For personal observations and the 'natural', unreflecting grasp of things that goes with them are both fallible and corrigible, and are being continually rectified and qualified, not only by mutual comparison, but also in the light of impersonal observations. Thus, we habitually compare the readings of outdoor thermometers or of wristwatches with the estimates of air temperature or of time elapsed based on our feelings; a practice which not only serves to control and to correct such estimates, but can also contribute significantly to improve their accuracy. Personal observation is not only not superior to impersonal observation as a source of knowledge about physical objects, but, in both scope and precision, it is on the whole markedly inferior. The confusion that still prevails in some philosophical circles on this fairly obvious and simple matter can only be attributed to a vicious craving for certainty. This, of course, will never be satisfied by impersonal observation

and its intricate scaffolding of theories. But neither can it be quenched by contracting one's knowledge claims to the bare subsistence level of common sense judgments and direct perceptions.

Personal observation is, of course, always required for the cognitive fulfilment of impersonal observation. It may therefore seem surprising that the latter can be more precise and reliable than the former. For a system for the transmission of information cannot perform better than its weakest component. The solution to this apparent paradox is not far to seek. Human sensors are not equally deficient for all tasks. They are rather bad at discriminating weights, or temperatures, or light intensities, and they are utterly incapable of detecting small changes in atmospheric pressure; but they are pretty good at reading clearly printed digits, and may be trusted to record a coincidence between a pointer and a thin black line on a white dial. Observation devices are designed to translate the often imperceptible effects of the observed object on the receiver into easily discernible digital or pointer readings. That the outcome of impersonal observations should thus ultimately appear in the guise of personally observed data led some philosophers to think that a faithful description of such personal observations in plain everyday language could give the full 'cognitive meaning' of the statements, couched in esoteric, 'theoretical' terms, in which scientists normally report their findings. Of course, in real life things stand just the other way around: digital and pointer readings get their distinctive interpretation from the theory of the respective instruments, and without it they all look quite insignificant and very much the same.

9 ON THE RELATION BETWEEN OBSERVED OBJECTS AND RECEIVER STATES

No difference can be observed in an object which is not recorded as a difference in the receiver. This principle is central to our current understanding of observation; and it does not seem possible to deny it, no matter how we revise or refine that understanding. Indeed, the principle is so deeply ingrained in our language that we would never be said to *observe* a change we know to occur in the object, but which our bodies and the instruments at our disposal do not reflect.

It follows that in any personal observation receiver states must mediate between the observed features of the object and the observer's perception of them. We are far from understanding the relation between those states, of which we are mostly unaware, and our awareness of the objective situations they disclose. That there is no simple correspondence between the information bearing states of our sense organs and any relevant states of mind can be readily gathered from the three examples on page 18. Only by sinking the cognitively significant receiver states deeper and deeper into the unexplored recesses of the brain could one hope to map them one-to-one onto the contents of our sense awareness. As neurology advances, such

terrae incognitae become increasingly unavailable, and one sees ever more clearly that a mind-brain isomorphism, if at all possible, could only be established on the basis of a thoroughly innovative, physically unorthodox description of the brain (*cf.* Searle [1983], p. 272). On the other hand, the relation between the said receiver states and the matching features of the object can be handled by the standard methods of physics. In this respect there is no essential difference between personal and impersonal observation. And indeed virtually all progress in the physiology of perception, since Kepler first conceived the eye on the analogy of the *camera obscura*, has been achieved by treating the organs of sense as impersonal receivers.

Object-receiver relations in personal and impersonal observations take varied forms and their study pertains to diverse fields of science. But they all share at least one common trait which must be considered in a philosophical discussion of observation. *A receiver state conveys information about the presence of a certain feature in an object only in so far as this feature is a necessary condition of that state.*

Consider impersonal observation. We assume that there is no difficulty in classifying and recognizing observationally significant receiver states. However, a definite receiver state will not, as a rule, unambiguously point to an equally definite feature in the object. Such a state can normally arise due to diverse conditions, some of which need not even concern the intended object of observation. (Precision measurements can be greatly impaired by thermal variations in the instruments employed.) But even where such perturbing factors are negligible, the distinguishable states of the receiver may not suffice to discriminate between significantly different properties of the object. A grey shadow on a medical X-ray picture can reflect all sorts of conditions in the patient's body. To judge what is actually disclosed by it, an observer must rely on his experience of similar X-ray pictures and on his general knowledge of medicine. A coupled pair of spots in a telescope photograph of a piece of sky is usually taken as evidence that in the direction of those spots there are two, possibly associated, astronomical light sources; but they might exceptionally be caused by a single source, if the beam of light it sends towards us is split, on the way to our telescope, by a gravitational lens. To decide that the latter is indeed the case an observer must carefully examine the circumstances in the light of gravitational theory. There are, indeed, plenty of cases in which the record of an impersonal observation tells an observer exactly what he wishes to know about an object, although he has no inkling of how the observation works and of what precisely is recorded by the receiver. Most of us ordinarily employ instruments of observation to learn about our surroundings in such a thoughtless way. But we can do so only because a vast repertoire of object-receiver correlations has been firmly established by scientific and technological research. Such research is all but thoughtless. It does not simply proceed by trying out any old instrument on a class of objects and setting up by straight-rule induction a correspondence between the alternative states

of the former and the interesting differences among the latter. The impersonal receivers in current use in all walks of life have for the most part been painstakingly developed in the light of scientific theories which entail certain necessary connections between diverse features of interest in our environment and directly observable receiver states. This is not the place to examine what type of necessity scientific theorising discovers—or induces—in nature. But one should bear in mind that impersonal observation is impossible without it. A particular receiver state can disclose a particular state of affairs only if the latter is, under the circumstances, a necessary condition of the former. To know this, one must grasp them both as instances of general types which stand in suitable relations of entailment to one another. Such typifications are not ready-made, but are the outcome of scientific thought. We may indeed unreflectingly profit from the impersonal observations with well-established significance which are taking place all about us. But we could not without reflection and theory-guided invention have brought them under way. There are some apparent exceptions—so called accidental discoveries—but ultimately they also confirm this rule. Thus, for example, a photographic plate stored together with a preparation of uranium salts from 27 February to 1 March 1896 inside a drawer of Henri Becquerel's laboratory, which was exposed notwithstanding the absence of light in the drawer, recorded the first observation of radioactivity; but it took Becquerel's alertness and preparedness—he himself had mounted the uranium salts on the plate to study their phosphorescence under sunlight, but no sun shone on Paris in those winter days—to grasp as an observation record what another one would have discarded as a spoilt plate.

Personal observation stands, physically, under the same principles as impersonal observation. A person cannot become aware, by observation, of a change in an object unless the latter effects a change in his body. A state of a human body can convey information about a feature of its surroundings only to the extent that this feature is a necessary condition of that state.[1] However, not every state of the body is a source of observational awareness; nor do those which are disclose every one of their necessary conditions.

[1] The following example might suggest that the above requirement is too stringent. Unbeknownst to me, John, the postman who brings the mail to my neighbourhood, has an identical twin, Jack, who also works for the Postal Service. Suppose that this morning, as I went out of my building, I saw a postman across the street, whom I immediately took to be John, and indeed John he was. One could then say that I knew John as soon as I saw him, and that the information was conveyed by my eyes. Yet John's presence across the street was not a necessary condition of the state of my optical receptors when I looked at him from my door, for a state indistinguishable from it would have been effected by the presence of Jack, in the same uniform and posture, at the same spot. Of course, had Jack been there, my brain would have reacted in the same way to the visual stimuli, and I would have mistaken him for John. I do not think, however, that the example proves that the requirement of necessity I stated in the text is excessive. What it shows, to my mind, is that the information conveyed by my eyes when I see the postman across the street suffices, *at most*, to establish that he is either John or Jack, and that my correct perception of him as being John goes beyond that information and involves a happy guess (aided, of course, by my ignorance of Jack's existence).

Observational awareness is selective: the observer's attention, guided by his interests and preconceptions, falls at any given time only on a small part of the current range of his consciousness. Observational awareness is self-transcending: it is no mere epiphany of organic states, but the grasp of an object against the background of a world. Hence, while in impersonal observation the facts of the matter must be inferred from a suitable description of the receiver states in the light of scientific theories and a general assessment of the circumstances (or by means of the 'inference tickets' provided by the user's manual that comes with the instrument), in personal observation the actual presence of such-and-such an object is not a conclusion that needs to be drawn deductively or inductively from the momentary state of our body, for we are, so to speak, pre-programmed to jump to it straight away. (*Cf.* Fodor [1984].) The observer's grasp of the object can be rectified to comply with earlier or further experiences, with scientific theories, or even with philosophical criticism. But it cannot be suppressed from observational awareness without destroying the latter's observational character. Thanks to his immediate grasp of the environment in which his body is placed, the human observer develops an understanding of observation as a physical process and increasingly sophisticated theories about object-receiver links. Such theories are not required to get personal observation going—indeed, they would not even be possible if observational awareness did not precede them—but they certainly change our grasp of what we observe personally. Their might is demonstrated by the total incapacity of this writer and—presumably— of the reader to see ghosts and to hear voices from another world, abilities which are not uncommon among people who have a different understanding of light and sound.

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